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Original article

Coracoacromial ligament section under ultrasonographic control: A cadaveric study on 20 cases

S. Delforge [a,*], B. Lecoq [b], C. Hulet [a], C. Marcelli [b]

[a] Département d'orthopédie-traumatologie, CHU de Caen, avenue Côte-de-Nacre, 14000 Caen, France
[b] Service de rhumatologie, CHU de Caen, avenue Côte-de-nacre, 14000 Caen, France

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ABSTRACT

Introduction: The coracoacromial ligament is a complex anatomical structure involved in the development of subacromial impingement; treatment is founded on sectioning the ligament, with or without associated arthroscopic acromioplasty and debridement.
Hypothesis: Complete coracoacromial ligament section can be performed under ultrasound, without lesion to surrounding structures.
Materials and methods: The coracoacromial ligament was sectioned on the coracoid side, under ultrasound navigation, in 10 cadavers donated to science: i.e. 20 shoulders. After ultrasound location of the shoulder structures, sectioning was performed with a skin incision at the level of the deltopectoral sulcus. Secondary surgical control checked conservation of the acromial branch of the thoracoacromial artery, and the quality of the procedure.
Results: Mean surgery duration was 18.5 minutes (± 5 min). Seventeen sections were complete (85%). Artery location was hampered by the impossibility of using Doppler on these cadavers, yet even so there were only 2 vascular lesions. There were no accidental rotator cuff or cartilaginous lesions.
Conclusion: This relatively non-invasive technique is quick and less heavy than open surgery, opening up new treatment perspectives. It could be indicated in coracoid and subacromial impingement before opting for surgery, or as a complement to surgery. It does, however, involve a learning curve and requires solid ultrasound skills.

1. Introduction

There have been numerous anatomic [1–3] and biomechanical [2,4,5] studies of the coracoacromial ligament (CAL). It is the main component of the acromial arch, its fibers uniting the acromion and the coracoid process. It usually comprises 2 bundles: a thick and resistant anterolateral bundle and a posteromedial bundle, with a triangular coracoid base [6] (Fig. 1). The proximal insertion takes up the anterior edge of the acromion, blending into the anterior fascia of the deltoid, and the distal end lies on the posteroinferior part of the coracoid process. The anterolateral bundle is in continuity with the lateral part of the conjoint tendon, while the posteromedial bundle terminates facing the anterior edge of the acromioclavicular joint [7]. Anatomic variants are frequent, found in almost 40% of cases. Y-shaped, quadrangular and straight forms have been reported, all greatly variable [8]. The relevant vascular structure is the acromial branch of the thoracoacromial artery, which passes over the coracoid process toward the acromioclavicular joint.

Although its role remains to be fully determined, the CAL is significantly involved in phenomena of subacromial impingement. It relays the forces acting on the coracoid process and acromion, attenuating the downward traction exerted by the conjoint tendon and pectoralis minor [9]. Repeated stress to the ligament can lead to the formation of a bone spur on the anterior edge of the acromion; ablating it and resecting the CAL abolishes pain in most cases [10–12]. For more than 10 years now, ultrasound has been an indispensable diagnostic and therapeutic tool [13,14], and all the more so with the introduction of high-frequency probes, the availability of numerous training modules and a fall in the price of the equipment. Recent reports on carpal tunnel surgery have testified to the interest of ultrasound navigation [15,16]. The "echo-surgery" concept could be applied to the shoulder. Ultrasound control allowed the incision to be reduced to less than 5 mm at the stump of the shoulder, replacing the arthroscopic "eye" or the surgeon's eye by an acoustic window: ultrasound. The present study assessed the feasibility of performing CAL section under ultrasound as a less invasive alternative option.

* Corresponding author. Tel.: +33 0 618888019.
E-mail address: delforge-s@chu-caen.fr (S. Delforge).

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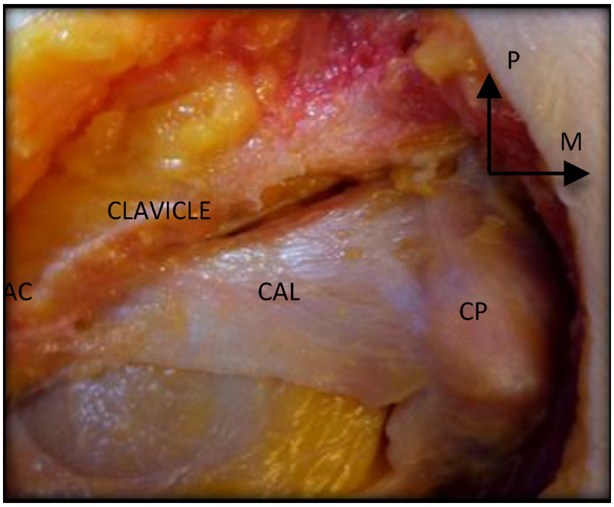

Fig. 1. Superior view of the acromial arch. AC: acromion; CP: coracoid process; CAL: coracoacromial ligament; BW: backward; IW: inward.

2. Material and method

2.1. Material

Twenty shoulders from 10 cadavers donated to science were selected for the absence of visible scar or deformity at the joint. Ultrasound with a 13 MHz probe was used during CAL section by a retractable blunt-tipped scalpel with protective cannula. The cadaver was in supine position, with the arm free along the body to facilitate anatomical land marking.

2.2. Method

2.2.1. First ultrasound step

The first step was performed by an experienced interventional ultrasonographer with expertise in upper limb exploration. The technique was first developed on a preliminary series of 20 shoulders. The first step consisted in determining ultrasound anatomy around the CAL and adjacent structures, focusing on locating vascular axes (Fig. 2). Once the technique had been perfected, a study was performed on the 20 shoulders donated to science, under conditions as close as possible to real life.

Fig. 2. Ultrasound location of the CAL satellite artery in a live patient.

The rotator cuff tendons, the long head of the biceps tendon, the acromion, the CAL and the coracoid process were located under ultrasound.

Surgery began with a 5-mm longitudinal incision under ultrasound guidance, the scalpel being introduced about 1 cm below and laterally to the tip of the coracoid process. The exact location of the incision was determined by ultrasound-anatomic findings and the trajectory was then delicately opened up using dissection scissors. The dedicated cannula of the retractable blunt-tipped scalpel was then introduced between the CAL, below, and the acromial branch of the thoracoacromial artery, above, with the blade retracted.

Once in place, the cannula was positioned for cutting, with the retrograde scalpel blade extended. The scalpel was first positioned horizontally, parallel to the ligament, so as to maximize the shadow cone for optimal location, and then turned vertically to cut. The entire length of the CAL was sectioned in a retrograde direction under strict ultrasound control. As there was a single operator, ultrasound monitoring and sectioning could be synchronized. After the first section, the scalpel was withdrawn and complete ligament sectioning was controlled by palpating the ligament with the cannula in the safety position, to look for any possible "straps"; if sectioning was incomplete, the operation was repeated.

2.2.2. Second surgical step

Surgical control was performed immediately after the first step, on a deltopectoral approach through the scalpel entry hole. The CAL, the acromial branch of the thoracoacromial artery and the antero-superior cuff (long head of the biceps tendon, subscapularis and anterior edge of the supraspinatus) were located. Completeness of CAL sectioning at the base of the coracoid process and the integrity of neighbouring structures were checked and results were entered in a spreadsheet.

3. Results

Table 1 shows the results of sectioning in the various cadavers.

Mean ultrasound-guided procedure time was 18.5 min (range, 10–27 min), growing shorter on a learning curve in the last 10 cases.

Surgical revision found 17 complete (85%) and 3 incomplete CAL sections (15%) (Figs. 3, 4). The acromial branch of the thoracoacromial artery was spared in 90% of cases ($n = 18$): i.e., only 2 cases of arterial lesion.

Table 1
Results of CAL section in 20 shoulders.

Number	Complete Section	Arterial lesion	Procedure duration (minutes)
1	No	No	27
2	Yes	No	26
3	Yes	No	23
4	Yes	Yes	21
5	Yes	No	25
6	No	No	19
7	Yes	No	22
8	Yes	No	20
9	Yes	No	20
10	Yes	No	10
11	Yes	No	20
12	Yes	No	15
13	No	Yes	19
14	Yes	No	20
15	Yes	No	15
16	Yes	No	15
17	Yes	No	15
18	Yes	No	12
19	Yes	No	10
20	Yes	No	15

Fig. 3. Location of incision area.

The 3 incomplete sections all concerned Y-shaped ligaments in which only the anterior bundle, separated from the posterior bundle by a supple membrane, had been sectioned.

Open exploration found no cartilage lesions on the humeral head, such as could have been caused by the scalpel. No rotator cuff delamination was observed.

4. Discussion

The present cadaver study demonstrated the feasibility of ultrasound-guided CAL sectioning on the coracoid side, with a low rate of complications. Using a retractable scalpel blade and pre-locating the anatomic structures of the scapular region on ultrasound enabled reliable and effective sectioning. Our experience in endoscopic carpal tunnel release led to the development of a retractable blunt-edged scalpel, allowing palpation control of the coracoid process and CAL remnants, reducing the risk of accidental lesion and improving surgical precision.

Two of the 3 incomplete sections were performed early in the study, and procedure time also decreased with experience. The acromial branch of the thoracoacromial artery was very difficult to locate in the absence of Doppler. The number of vascular lesions (only 2 in the present series) should diminish greatly in surgery on live patients, where ultrasound allows prior location of the artery and cephalic vein so that the cannula and the scalpel can be positioned at a safe distance for sectioning.

The great anatomic variability of the CAL was one reason underlying the 3 cases of incomplete sectioning, which occurred in Y-shaped ligaments, with only the thicker and wider anterior bundle being sectioned. The posterior bundle is also liable to be overlooked in arthroscopic subacromial debridement: it is a more medial anatomic region, in contact with the clavicle, subject to bleeding [17], which impedes arthroscopic sectioning. The posterior bundle may be the Y-shaped Caldani or medial coracoclavicular ligament, but does not seem to be involved in subacromial impingement [18].

The procedure has certain limitations and raises certain questions that require answering. Ultrasound cannot replace arthroscopy, as it does not allow the association of several procedures: neither acromioplasty nor bursectomy can be performed endoscopically. CAL regrowth is an argument for resection rather than simple sectioning, to prevent recurrence of impingement, as demonstrated by Levy et al. [19]. The present series was small; results need confirming on studies of larger numbers of specimens.

Successful implementation requires a surgical environment allowing cross-over in case of complications (hematoma, tendon lesion, etc.). The technique should be part of the surgeon's arsenal, and involves a learning curve with respect to ultrasound skills. Ultrasound-guided CAL sectioning may be of therapeutic interest in certain target pathologies, notably the various forms of shoulder impingement.

Coracoid impingement underlies chronic anterior shoulder pain. Physiopathology remains controversial [20,21]. It involves impingement between the anterior cuff (subscapularis or long head of the biceps tendon) and the coracoid process [22–24]. Diagnosis is difficult, and based on measuring the coraco-humeral distance and on external maneuvers [25]. Treatment is primarily conservative, by rehabilitation (gestural reprogramming, avoidance of risky

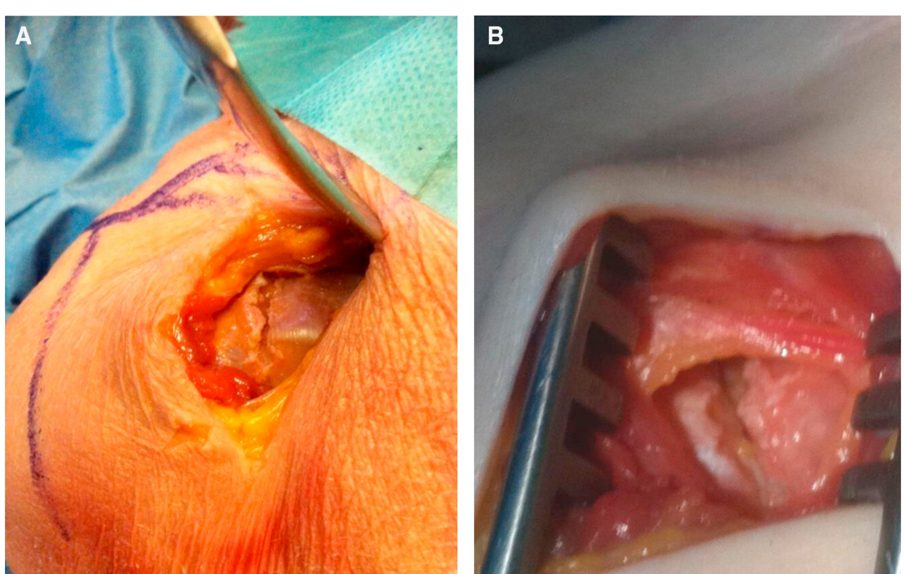

Fig. 4. A-B. Complete ligament section. Surgical control.

maneuvers, muscle reinforcement and scapular stabilization). In case of failure, second-line treatment is surgical, using arthroscopic or open coracoplasty, which provides good results [20,26]. Sectioning the CAL on the coracoid side may be an option to avoid surgery. The initial ultrasound step consists in confirming diagnosis by measuring the coraco-humeral distance and revealing the impingement by dynamic maneuvers in 90° adduction-flexion [27–29]. A complementary xylocaine infiltration test may be performed, and the CAL sectioned if diagnosis is confirmed.

Subacromial impingement (impingement syndrome) is a concept of controversial etiopathogenesis [30,31]. The cuff comes into conflict with the acromial arch, inducing stiffening of the CAL and the formation of a bone spur on the anterolateral side of the acromion [32–34]. Acromioplasty associated to debridement and CAL section restores a gliding space, with good results [35,36]. The rates of failure (10–20% residual pain) and complications are non-negligible [35,36]. The present, less invasive, technique is suited to subacromial impingement without bone spur. Several studies have demonstrated the variability of subacromial pressure depending on the position of the limb [37,38]. Ultrasound confirms diagnosis, then CAL section releases the acromial arch, thereby reducing pressure in the subacromial space.

This non-invasive and inexpensive "echo-surgical" technique may provide another option in medical management of subacromial impingement, especially in fragile and high-risk patients. It is performed under local anesthesia with sedation, thus avoiding the problems of general anesthesia and the need for hospital stay. It should be performed by an operator able to deal with the potential complications: i.e. preferably a surgeon.

5. Conclusion

This preliminary study confirms the feasibility of ultrasound-guided CAL section. Ultrasound (coupled to Doppler in live patients) confirms diagnosis and patient selection. Clinical applications are in well-defined pathologies such as coracoid impingement or antero-lateral acromial impingement without bone spur. The procedure is relatively non-invasive and can be performed on a day-hospital basis by a surgeon trained in ultrasound techniques. Ultrasound-guided CAL section is a complement rather than an alternative to surgery.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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